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Low temperatures related to surface wind speed and direction at London Airport, Dec. 1948 - Feb. 1958.

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INTRODUCTION

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Hourly observations of temperature and surface wind for the ten winters from December 1948 to February 1958 at London Airport were analysed for temperature at or below thresholds of 36, 34, 32, 30, 28 and 26°F. and associated wind speed at or above 5, 10 and 15 knots, for sequences of 6, 12, 18 and 24 hours, the results being shown in tabulated and graphical form. Winter was taken as December, January and February.

PROCEDURE

Sequences of six or more consecutive hours satisfying the above temperature and wind criteria were extracted by Hollerith machine methods, indicative data (comprising the year, month, day and hour of commencement of the sequence) being tabulated in addition to the temperature and wind data. If a sequence extended over a period greater than six hours, indicative data for the first hour of each consecutive 6-hr. period contained within the overall sequence were tabulated and, in addition, the total number of hours in the sequence was shown. It was hoped to ignore a break of only one hour in an otherwise unbroken sequence but this was found to be impracticable with the machines available.

For convenience of description and tabulation, the term "6-hr. sequence" will be used for a sequence satisfying the criteria for 6-11 hours, the term "12-hr. sequence" for a sequence satisfying the criteria for 12-23 hours, etc. A 12-hr. sequence is regarded as contributing two (or three) 6-hr. sequences in the frequency table for the latter, an 18-hr. sequence (i.e. 18-35 hr.) as contributing three (four or five) 6-hr. sequences, etc., depending on the total number of hours in the sequence.

Frequency tables were prepared for 6-hr. sequences using the wind direction reported at the first hour of each complete six-hour period; this involved a weakness that, for example, a 6-hr. sequence of maximum length (namely, 11 hours) would be allocated the wind direction reported at the first hour, but it is thought that the resulting error over ten winters is negligible, especially as wind speeds of less than 5k. (i.e. winds likely to be more variable in direction) are not included in this investigation. Wind directions were tabulated for each 10° of the compass and reduced to 8 points according to the conventions:-

$$\begin{aligned}
N &= \tfrac{3}{4}(34) + (35) + (36) + (01) + \tfrac{3}{4}(02) \\
NE &= \tfrac{1}{4}(02) + (03) + (04) + (05) + (06) + \tfrac{1}{4}(07) \\
E &= \tfrac{3}{4}(07) + (08) + (09) + (10) + \tfrac{3}{4}(11) \\
SE &= \tfrac{1}{4}(11) + (12) + (13) + (14) + (15) + \tfrac{1}{4}(16) \qquad \text{etc.}
\end{aligned}$$

Frequency tables were then prepared for the 12hr. sequences, wind direction being taken as the mean of the directions at the first hour of each of the first two six-hour periods i.e. the arithmatic mean of the directions at the 1st and 7th hours. Similarly, in frequency tables for 18-hr. sequences, wind direction was taken as the mean of the directions at the 1st, 7th. and 13th. hours, and, in frequency tables for 24-hr. sequences, the wind direction was taken as the mean of the directions at the 1st., 7th., 13th. and 19th. hours. No difficulties were encountered in this procedure of taking the arithmetic mean, as the fluctuations in wind direction throughout all sequences were relatively small.

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TABULATIONS

Table 1 gives the number of occasions in ten winters of 6, 12, 18 and 24-hr. sequences of temperature at or below stated thresholds of 36, 34, 32, 30, 28 and 26°F. with wind speed at or above 5, 10 and 15 knots, related to wind direction from each of the eight points of the compass.

Application of the conventions used to reduce wind directions, reported to the nearest 10°, to an 8-point scale, coupled with the effect of taking the representative wind direction as that reported at the first hour of each 6-hr. sequence, accounts for some small inconsistencies apparent in the tables e.g. from the table for 6-hr. sequences and for wind speed $\geqslant$ 5k.:-

with temp. $\leqslant$ 28, frequency from direction S. is 0, but
" " $\leqslant$ 26, " " " " " $\frac{3}{4}$.

This kind of inconsistency may be best explained by an example, thus:-

Hour	1	2	3	4	5	6	7	8
Temp. °F.	27	26	25	25	25	26	26	26
Wind speed (k.)	5	5	5	5	5	5	5	4
Wind direction (tens of degrees)	03	02	02	03	03	02	02	02

For temp. $\leqslant$ 28, hours 1-7 constitute a "6-hr. sequence" from direction 03 (at hour1);
contributing to frequency from N. is 0, and
" " " " NE. is 1.

For temp. $\leqslant$ 26, hours 2-7 constitute a 6-hr. sequence from direction 02 (at hour 2);
contribution to frequency from N is $\frac{3}{4}$, and
" " " " NE is $\frac{1}{4}$.

It was not considered profitable to extend Table 1 for sequences longer than 24 hours (i.e. lasting 24-47 hours) as the frequencies in the ten winters were too small. Table 2 gives, however, the longest sequence satisfying each of the indicated criteria of temperature and wind speed which occurred during the ten winters under review; the mean wind direction of each of these longest sequences is shown, this mean being derived from the directions reported at hours 1, 7, 13, 19, 25, ... etc.

GRAPHS

The graphs of fig.1 are all drawn using the same vertical scale of frequency in ten winters and correspond to the values in Table 1.

Fig.2 displays two curves A and B which serve, for purposes of discussion, to separate the wind and temperature factors incorporated in curve (a) of Fig.1 (i); curve A shows the variation with direction of the frequency of 6-hr. sequences (at London Airport during the same ten winters) with wind speed $\geqslant$ 5k. irrespective of temperature; curve B shows the percentage frequency of these sequences with temperature $\leqslant$ 36°F.

DISCUSSION OF RESULTS

The outstanding feature of all the curves of fig.1* is that the maximum frequency of cold spells of weather is associated with NE'ly. surface winds. Fig.2 (curve A) shows a secondary maximum from this direction of all spells of 6-11 hours with wind speed $\geqslant$ 5k., which partly reflects the greater persistence of winds from the NE. or E. sectors; curve B of fig.2 shows that nearly 47% of the NE'ly. 6-hr. sequences have their temperature $\leqslant$ 36°F. as compared with about 4% of the SW'ly sequences. Reference to the Climatological Atlas of the British Isles shows that for the winter season (and indeed for the year as a whole) Croydon, for the period 1922-38, had a higher frequency of wind from the NE. than from either N. or E., and it is probable that this is true for London Airport also.

* with the exception of fig.1 (ix) for which the data sample is very small.

Another noteworthy feature is the secondary maximum of frequency of W'ly. winds of speed $\geq$ 5k. maintained for 6-11 hours (fig.1 (i)) with temperature at or below 36, 34, 32 or 30°F. It is seen from curve A of fig.2 that the frequency of all spells of 6-11 hours with wind speed $\geq$ 5k. is approximately the same for winds from W. as for SW., but curve B shows that the percentage frequency of these spells with temperature $\leq$ 36°F. is approximately three times greater for W'ly. than for SW'ly winds.

NOTES ON PRESSURE DISTRIBUTIONS

The NE'ly regime of surface wind over southern England is frequently governed by a slow-moving or stationary high pressure system centred over Scandinavia or a belt of high pressure from Scotland to Scandinavia, together with low pressure over or near the Mediterranean, and this situation tends to be rather persistent. For example, Table 2 shows that the longest sequences satisfying the given criteria of temperature and surface wind speed occur mostly in the NE. sector, except for sequences with wind speed $\geq$ 15k., the longest of which occurred with N'ly winds.

Many different types of pressure distribution give a W'ly regime of surface wind over southern England but the type most likely to give conditions satisfying the given criteria of temperature and wind speed requires low pressure somewhere between Iceland and the Baltic, or over the North Sea, with high pressure to SW. or W. of the British Isles; the source region of the air over southern England is then frequently far to the north of the British Isles.

TABLE 1. Number of 6, 12, 18 and 24-hour sequences in ten winters satisfying stated criteria of temperature (in °F.) and wind speed (in knots).

London Airport, Dec. 1948–Feb. 1958.

6-hr. sequences

Temp. ≤ / Wind speed ≥	36			34			32			30			28			26		
	5	10	15	5	10	15	5	10	15	5	10	15	5	10	15	5	10	15
N	87	20¾	7	48	14	1¾	30¾	9¼	3½	15¾	1⅓	¾	9½			5⅗		
NE	132⅛	50	2¾	89¾	32	3	60¼	22¾	¼	40	19		23¼	10¾		12⅘	5¼	
E	61¾	24¼	3	39¼	19¾		27	12⅓		16½	7¼		8¼	3¼		3⅗	¾	
SE	25¼	8¾	1	10½	6½	1	5	3¼		1								
S	14¾	1		7⅓	1		2¾	1		1						¾		
SW	24⅕	1⅕		16½			3¾			2¼			1¼			¾		
W	74¼	9¼	1	47¼	1		21½			12¼			6½			1⅖		
NW	71	11½	¾	33¼	5¾	¼	19	4¼	¼	11¼	1¼	¼	8¼			2½		

12-hr. sequences

Temp. ≤ / Wind speed ≥	36			34			32			30			28			26		
	5	10	15	5	10	15	5	10	15	5	10	15	5	10	15	5	10	15
N	29	4¾	¾	14¾	3	1	9½	2	2	3			3			⅖		
NE	59	16¾	¾	35½	12	1	21	6		15½	3¼		7⅓	1⅓		3¾	1	
E	23	7¼	1½	19	6¾		13¾	5¾		6½	3¾		2½	1½		1		
SE	6¼	2¼		2¾	2¼		½	¼										
S	5⅗			2¾														
SW	¾			2¼														
W	17¾	1		9			2¾			2¾			¾					
NW	23½	2	1	13	2		6½	2		3¼			2¼					

18-hr. sequences

Temp. ≤ / Wind speed ≥	36			34			32			30			28			26		
	5	10	15	5	10	15	5	10	15	5	10	15	5	10	15	5	10	15
N	11¾	2¾	¾	5	¾	¾	4¼	1	1	¾			⅗					
NE	35	5½	½	17¾	3	¼	10⅓	1¾		7	1		4¼			3		
E	10¼	4½	¾	8½	2¼		3¼	2¼		4¼	2		1					
SE	4	1¼		2½	2		1											
S	3																	
SW																		
W	4																	
NW	10	1		5¼	1		1			1								

24-hr. sequences

Temp. ≤ / Wind speed ≥	36			34			32			30			28			26		
	5	10	15	5	10	15	5	10	15	5	10	15	5	10	15	5	10	15
N	6½	1	¾	2¾	1	¾	2¾	1	1	¾			¾					
NE	24	3½	½	14½	1¼	¼	9½	½		5½			3¼					
E	9¼	1½	¾	6¾	¾		1¾	1½		1¾								
SE	1¼			1														
S	1																	
SW																		
W	2¼																	
NW	3¾			4			1											

TABLE 2. – Longest sequence (in hours) satisfying the indicated criteria. The mean wind direction of each sequence is shown in brackets.

London Airport, Dec. 1948–Feb. 1958

Temp. ≤ / Wind speed ≥	36	34	32	30	28	26
5	152 (060)	101 (040)	65 (050)	50 (030)	30* (020 and 060)	23 (060)
10	31* (360 and 040)	30 (070)	30 (070)	21 (080)	15 (070)	12 (070)
15	31 (360)	28 (010)	25 (360)	9 (340)	–	–

* Two sequences of the same length.

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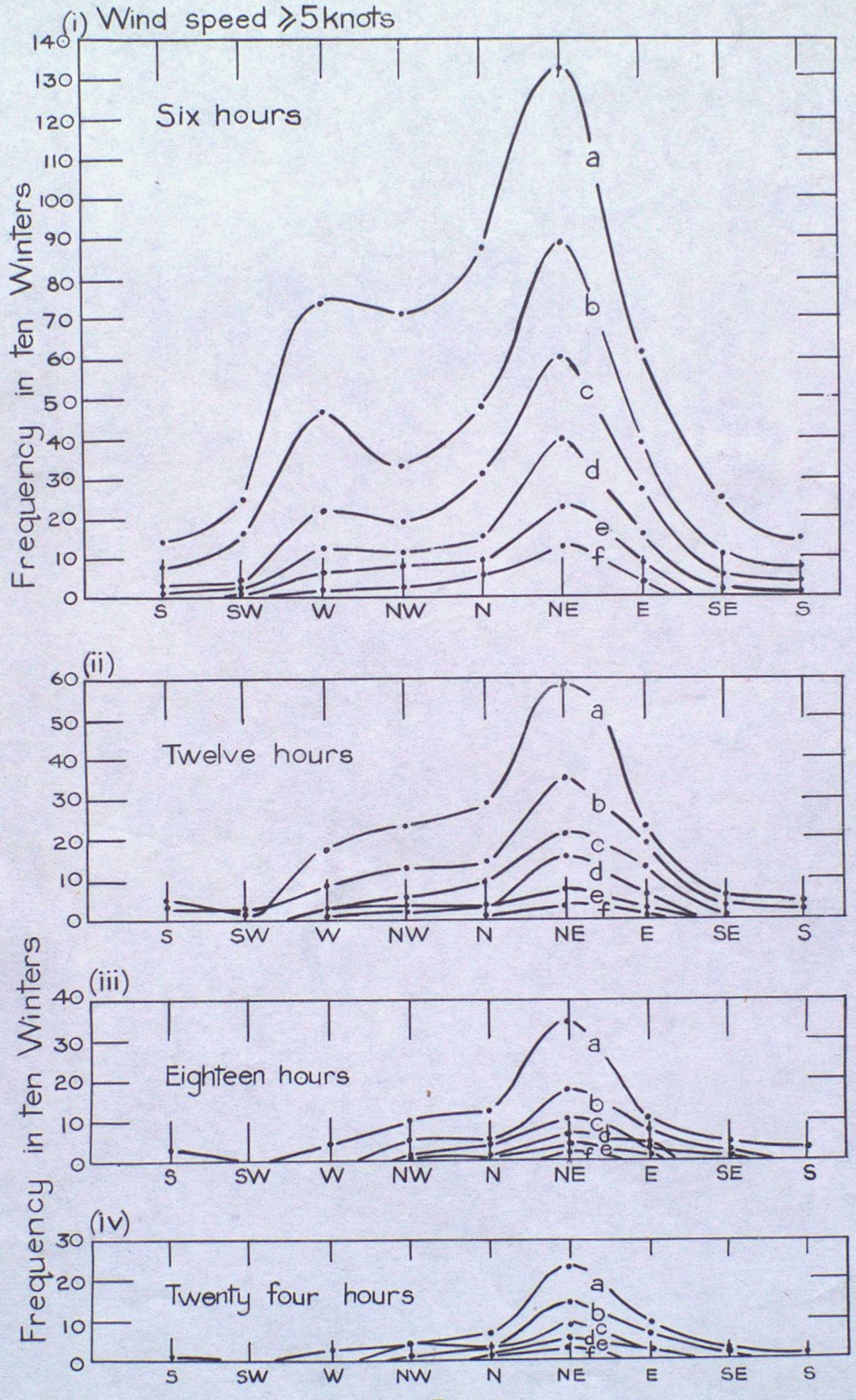


Fig. 1

a: $T \leq 36°F$

b: $T \leq 34°F$

c: $T \leq 32°F$

d: $T \leq 30°F$

e: $T \leq 28°F$

f: $T \leq 26°F$

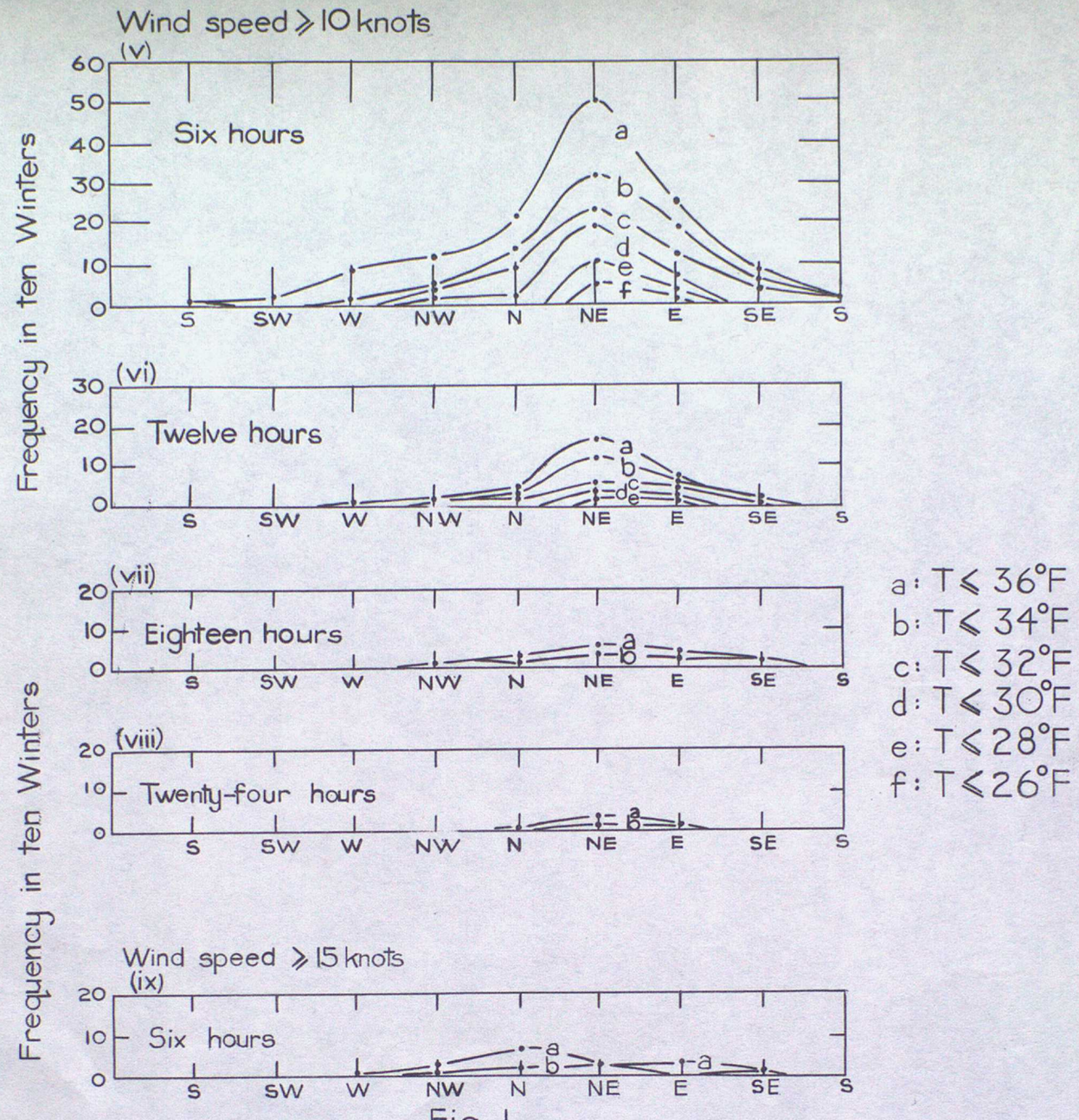
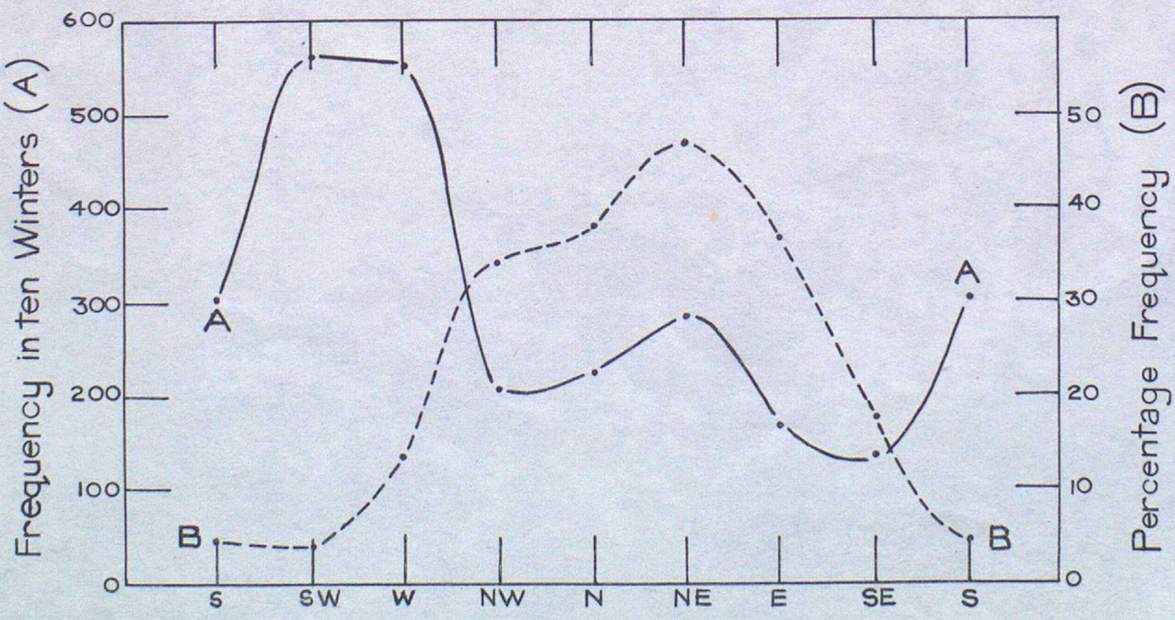


Fig. 1



Curve A Frequency of spells of 6–11 hrs with wind speed ⩾ 5 kt. from given directions irrespective of temperature

Curve B Percentage frequency of the above spells with temperature ⩽ 36°F.

Fig. 2